

**Claims**

What is claimed is:

1 1. Carbon nanofibers comprising fibrillated fibers having a Canadian  
2 Standard Freeness of less than about 100 or a fiber diameter of less than or  
3 equal to about 400 nm carbonized at a temperature of less than about  
4 600°C.

1 2. Carbon nanofibers of claim 1 wherein said fibrillated fibers are  
2 activated in an oxidizing atmosphere at elevated temperature to form  
3 activated carbon nanofibers.

1 3. Carbon nanofibers of claim 2 further including a microbiological  
2 interception enhancing agent.

1 4. Carbon nanofibers of claim 2 wherein said activated carbon  
2 nanofibers can be formed into an activated carbon nanofiber sheet.

1 5. Carbon nanofibers of claim 1 wherein said carbon nanofibers can be  
2 formed into a carbon nanofiber sheet.

1 6. Carbon nanofibers of claim 1 further including a microbiological  
2 interception enhancing agent.

1 7. A filter medium comprising the carbon nanofibers of claim 1.

1 8. A sheet comprising fibrillated fibers having a Canadian Standard  
2 Freeness of less than about 100 or a fiber diameter of less than or equal to  
3 about 400 nm carbonized at a temperature of less than about 600°C.

1 9. A sheet of claim 8 wherein said sheet is further heated to form an  
2 activated carbon sheet having a BET surface area of greater than about 800  
3 m<sup>2</sup>/g.

1 10. A sheet of claim 8 wherein the fibrillated fibers have a Canadian  
2 Standard Freeness of less than about 45 or a fiber diameter of less than about  
3 250 nm.

1 11. A sheet of claim 8 wherein the fibrillated fibers have a Canadian  
2 Standard Freeness of less than about 0 or a fiber diameter of less than about  
3 250 nm.

1 12. A sheet of claim 8 wherein the fibrillated fibers comprise polymers,  
2 liquid crystal polymers, engineered resins, cellulose, rayon, ramie, wool, silk,  
3 or combinations thereof.

1 13. A sheet of claim 8 wherein the fibrillated fibers comprise lyocell.

1 14. A sheet of claim 8 further including active agents captured therein.

1 15. A sheet of claim 14 wherein the active agents comprise metals, metal  
2 salts, metal oxides, glass, alumina, carbon, activated carbon, silicates,  
3 ceramics, zeolites, diatomaceous earth, activated bauxite, fuller's earth,  
4 calcium sulfate, titanium dioxide, magnesium hydroxide, manganese oxides,  
5 magnesia, perlite, talc, clay, bone char, pitch, calcium hydroxide, calcium  
6 salts, or combinations thereof.

1 16. A sheet of claim 8 further including a microbiological interception  
2 enhancing agent.

- 1 17. A sheet of claim 8 wherein the fibrillated fibers are admixed with
- 2 active agents, and made into a paper prior to carbonization.
- 1 18. A sheet of claim 8 wherein said sheet is used as an electrode.
- 1 19. A sheet of claim 8 further including a catalyst or a catalyst support.
- 1 20. A filter medium comprising the sheet of claim 8.
- 1 21. A sheet comprising activated, carbonized fibrillated fibers having a  
2 BET surface area of greater than about 800 m<sup>2</sup>/g, wherein, prior to  
3 carbonization and activation, the fibrillated fibers have a Canadian Standard  
4 Freeness of less than about 100 or a fiber diameter of less than or equal to  
5 about 400 nm and wherein activation occurs in less than or equal to about  
6 30 minutes at a temperature greater than about 875°C in an oxidizing  
7 atmosphere.
- 1 22. A sheet of claim 21 wherein the fibrillated fibers have a Canadian  
2 Standard Freeness of less than about 45 or a fiber diameter of less than or  
3 equal to about 250 nm.
- 1 23. A sheet of claim 21 wherein the fibrillated fibers have a Canadian  
2 Standard Freeness of less than about 0 or a fiber diameter of less than or  
3 equal to about 250 nm.
- 1 24. A sheet of claim 21 wherein the fibrillated fibers comprise polymers,  
2 liquid crystal polymers, engineered resins, cellulose, rayon, ramie, wool, silk,  
3 or combinations thereof.
- 1 25. A sheet of claim 21 wherein the fibrillated fibers comprise lyocell.

- 1 26. A sheet of claim 21 further including active agents captured therein.
- 1 27. A sheet of claim 26 wherein the active agents comprise metals, metal  
2 salts, metal oxides, glass, alumina, carbon, activated carbon, silicates,  
3 ceramics, zeolites, diatomaceous earth, activated bauxite, fuller's earth,  
4 calcium sulfate, titanium dioxide, magnesium hydroxide, manganese oxides,  
5 magnesia, perlite, talc, clay, bone char, pitch, calcium hydroxide, calcium  
6 salts, or combinations thereof.
- 1 28. A sheet of claim 21 wherein the fibrillated fibers are admixed with  
2 active agents, and made into a paper prior to carbonization and activation.
- 1 29. A sheet of claim 21 further including a catalyst or a catalyst support.
- 1 30. A sheet of claim 21 further including a microbiological interception  
2 enhancing agent.
- 1 31. A filter medium comprising the sheet of claim 21.
- 1 32. A sheet comprising carbonized fibrillated fibers having a Canadian  
2 Standard Freeness of less than about 45 or a diameter of less than or equal to  
3 about 250 nm, and active agents captured within said carbon sheet, said  
4 active agents present in an amount greater than about 10 weight percent of a  
5 total weight of said sheet.
- 1 33. A sheet of claim 32 wherein said active agents comprise metals, metal  
2 salts, metal oxides, glass, alumina, carbon, activated carbon, silicates,  
3 ceramics, zeolites, diatomaceous earth, activated bauxite, fuller's earth,  
4 calcium sulfate, titanium dioxide, magnesium hydroxide, manganese oxides,  
5 magnesia, perlite, talc, clay, bone char, pitch, calcium hydroxide, calcium  
6 salts, or combinations thereof.

1 34. A sheet of claim 32 wherein said active agents are present in an  
2 amount of greater than 50 weight percent.

1 35. A sheet of claim 32 wherein said active agents have a particle size of  
2 less than about 50  $\mu\text{m}$  and are present in an amount of greater than 97  
3 weight percent.

1 36. A sheet of claim 32 wherein said sheet is used as an electrode.

1 37. A sheet of claim 32 further including a catalyst or a catalyst support  
2 incorporated therein.

1 38. A sheet of claim 32 further including a microbiological interception  
2 enhancing agent.

1 39. A filter medium comprising the sheet of claim 32.

1 40. A sheet comprising activated, carbonized fibrillated fibers wherein the  
2 fibrillated fibers have a Canadian Standard Freeness of less than about 45, a  
3 diameter of less than or equal to about 250 nm, and active agents captured  
4 therein, wherein the active agents are present in an amount greater than  
5 about 10 weight percent of a total weight of said sheet.

1 41. A sheet of claim 40 wherein said active agents comprise metals, metal  
2 salts, metal oxides, glass, alumina, carbon, activated carbon, silicates,  
3 ceramics, zeolites, diatomaceous earth, activated bauxite, fuller's earth,  
4 calcium sulfate, titanium dioxide, magnesium hydroxide, manganese oxides,  
5 magnesia, perlite, talc, clay, bone char, pitch, calcium hydroxide, calcium  
6 salts, or combinations thereof.

1 42. A sheet of claim 40 further including a catalyst or a catalyst support.

1 43. A sheet of claim 40 further including a microbiological interception  
2 enhancing agent.

1 44. A filter medium comprising the sheet of claim 40.

1 45. A process of continuously making carbon nanofibers comprising the  
2 steps of:

3 providing fibrillatable fibers;  
4 fibrillating the fibers to a Canadian Standard Freeness of less  
5 than about 100 or to a fiber diameter of less than or equal to about  
6 400 nm, or both; and  
7 carbonizing the fibrillated fibers at a temperature of less than  
8 about 600°C.

1 46. A process of claim 45 wherein the step of providing an organic fiber  
2 comprises providing organic fibers selected from the group consisting of  
3 polymers, liquid crystal polymers, engineered resins, cellulose, rayon, ramie,  
4 wool, silk, and combinations thereof.

1 47. A process of claim 45 wherein in the step of fibrillating, the fibers are  
2 fibrillated to a Canadian Standard Freeness of less than or equal to about 45  
3 of a fiber diameter of less than or equal to about 250 nm.

1 48. A process of claim 45 wherein in the step of fibrillating, the fibers are  
2 fibrillated to a Canadian Standard Freeness of less than or equal to  
3 about 0 or a fiber diameter of less than or equal to about 250 nm.

1 49. A process of claim 45 further including the step of activating the  
2 carbonized fibrillated fibers in an oxidizing atmosphere at a temperature of  
3 greater than about 875°C for less than or equal to about 30 minutes.

1 50. A process of claim 45 further including the step of treating the  
2 carbonized fibrillated fibers with a microbiological interception enhancing  
3 agent.

1 51. A process of claim 45 further including the step of adding gases during  
2 the step of carbonizing the fibrillated fibers such that functional groups are  
3 formed on a surface of the carbonized fibrillated fibers.

1 52. A process of claim 45 further including the step of incorporating a  
2 catalyst into the carbonized fibrillated fibers.

1 53. A process of continuously making a carbon sheet comprising the steps  
2 of:

3 forming a precursor paper from fibrillated fibers on a paper  
4 making machine wherein the fibrillated fibers have a Canadian  
5 Standard Freeness of less than about 100 or a diameter of less than or  
6 equal to about 400 nm; and

7 carbonizing the precursor paper to form a carbon nanofiber  
8 sheet, wherein the carbonization occurs at a temperature of less than  
9 about 600°C.

1 54. A process of claim 53 wherein the step of forming a precursor paper  
2 comprises forming a paper from fibrillated fibers having a Canadian Standard  
3 Freeness of less than about 45 or a fiber diameter of less than or equal to  
4 about 250 nm.

1 55. A process of claim 53 wherein the step of forming a precursor paper  
2 comprises forming a precursor paper from fibrillated fibers having a Canadian  
3 Standard Freeness of less than about 0 or a fiber diameter of less than or  
4 equal to about 250 nm.

1 56. A process of claim 53 wherein the step of forming a precursor paper  
2 comprises forming a precursor paper from fibrillated lyocell fibers.

1 57. A process of claim 53 wherein the step of forming a precursor paper  
2 further includes admixing the fibrillated fibers with active agents comprising  
3 metals, metal salts, metal oxides, glass, alumina, carbon, activated carbon,  
4 silicates, ceramics, zeolites, diatomaceous earth, activated bauxite, fuller's  
5 earth, calcium sulfate, titanium dioxide, magnesium hydroxide, manganese  
6 oxides, magnesia, perlite, talc, clay, bone char, pitch, calcium hydroxide,  
7 calcium salts, or combinations thereof.

1 58. A process of claim 53 further including the step of adding gases during  
2 the step of carbonizing the precursor paper such that functional groups are  
3 formed on a surface of the carbonized fibrillated fibers.

1 59. A process of claim 53 further including the step of activating the  
2 carbon nanofiber sheet by heating the carbon sheet at a temperature greater  
3 than about 875°C for less than or equal to about 30 minutes in an oxidizing  
4 atmosphere.

1 60. A process of making an activated carbon nanofiber sheet comprising  
2 the steps of:  
3 forming a precursor paper of fibrillated nanofibers on a paper  
4 making machine wherein the fibrillated nanofibers have a Canadian

5 Standard Freeness of less than about 100, a diameter of less than or  
6 equal to about 400 nm, or a combination thereof;  
7 carbonizing the precursor paper; and  
8 activating the carbonized precursor paper in an oxidizing  
9 atmosphere at elevated temperatures to form an activated carbon  
10 nanofiber sheet.

1 61. A process of claim 60 wherein the steps of carbonizing and activating  
2 occur in a single heating step.

1 62. A process of claim 60 wherein the step of forming a precursor paper  
2 comprises forming a precursor paper from fibrillated lyocell fibers.

1 63. A process of claim 60 wherein the step of forming a precursor paper  
2 further includes admixing the fibrillated fibers with particles comprising one  
3 of carbon, activated carbon, inorganic particles, or a combination thereof.

1 64. A method of claim 60 wherein the step of activating the carbonized  
2 precursor paper occurs at a temperature of greater than about 875°C for less  
3 than or equal to about 30 minutes.

1 65. A process of claim 60 further including the step of adding gases during  
2 the step of carbonizing and activating the precursor paper such that  
3 functional groups are formed on a surface of the carbonized and activated  
4 fibrillated fibers.

1 66. A method of removing microbiological contaminants from a fluid  
2 comprising the steps of:  
3 providing a filter medium having a microporous structure  
4 comprising carbonized nanofibers having a Canadian Standard  
5 Freeness of less than about 100 or a fiber diameter of less than or

6       equal to about 400 nm, wherein the nanofibers are carbonized at a  
7       temperature of less than about 600°C;

8               contacting a microbiologically contaminated fluid with the  
9       filter medium;

10               removing the microbiological contaminants in the fluid by  
11       adsorption and interception within the medium.

1       67      A method of claim 66 wherein in the step of providing a filter medium  
2       having a microporous structure comprising carbonized nanofibers, the  
3       nanofibers are treated with a microbiological interception enhancing agent.

1       68.     A method of claim 67 wherein in the step of providing a filter medium  
2       having a microporous structure comprising carbonized nanofibers treated  
3       with a microbiological interception enhancing agent, the microbiological  
4       interception enhancing agent further includes a biologically active metal.

1       69.     A method of claim 66 wherein in the step of providing a filter medium  
2       having a microporous structure comprising carbonized nanofibers, the  
3       carbonized nanofibers are activated.

1       70.     A method of claim 69 wherein in the step of providing a filter medium  
2       having a microporous structure comprising a sheet of activated carbon  
3       nanofibers, the sheet further includes active agents captured therein.

1       71.     A method of claim 66 wherein in the step of providing a filter medium  
2       having a microporous structure comprising carbonized nanofibers, the filter  
3       medium comprises a sheet of carbonized nanofibers.

1       72.     A method of claim 71 wherein in the step of providing a filter medium  
2       having a microporous structure comprising a sheet of carbonized nanofibers,  
3       the sheet further includes active agents captured therein.

1    73. A method of claim 72 wherein in the step of providing a filter medium  
2    having a microporous structure comprising a sheet of carbonized nanofibers  
3    having active agents captured therein, the active agents comprise metals,  
4    metal salts, metal oxides, glass, alumina, carbon, activated carbon, silicates,  
5    ceramics, zeolites, diatomaceous earth, activated bauxite, fuller's earth,  
6    calcium sulfate, titanium dioxide, magnesium hydroxide, manganese oxides,  
7    magnesia, perlite, talc, clay, bone char, pitch, calcium hydroxide, calcium  
8    salts, or combinations thereof.

1    74. A method of claim 66 wherein the step of providing a filter medium  
2    having a microporous structure comprising carbonized nanofibers, the filter  
3    medium further includes active agents comprising metals, metal salts, metal  
4    oxides, glass, alumina, carbon, activated carbon, silicates, ceramics, zeolites,  
5    diatomaceous earth, activated bauxite, fuller's earth, calcium sulfate, titanium  
6    dioxide, magnesium hydroxide, manganese oxides, magnesia, perlite, talc,  
7    clay, bone char, pitch, calcium hydroxide, calcium salts, or combinations  
8    thereof.